EXECUTIVE SUMMARY

INTRODUCTION

Chemical solvents have been used for cleaning clothes since the mid-19th century. Perchloroethylene (PCE) has been the solvent of choice for commercial clothes cleaning applications since the 1960s, although the volume used by drycleaners has declined significantly over the last decade. Despite this decline, a variety of health and safety issues associated with PCE use and increased regulation of the chemical have compelled the U.S. Environmental Protection Agency (USEPA), industry, and environmental groups to address concerns about PCE emissions. As part of an effort to explore opportunities for pollution prevention and reduce exposure to traditional drycleaning chemicals, the EPA's Design for the Environment (DfE) Garment and Textile Care Program has developed the *Cleaner Technologies Substitutes Assessment* (CTSA)*: Professional Fabricare Processes*.

The goal of the CTSA is to provide comparative cost, risk, and performance information on professional fabricare technologies. The audience for the CTSA is technically informed and might consist of individuals such as environmental health and safety personnel, owners, equipment manufacturers, and other decision makers. It is expected to be used as a technical supplement by USEPA and stakeholders to develop information products suitable for a broad audience. These products will help professional cleaners make informed technology choices that incorporate environmental concerns.

The CTSA is based upon readily available information and uses simplifying assumptions and conventional models to provide general conclusions about various cleaning technologies. It is not a rigorous risk assessment of chemicals used in the fabricare industry and should not be used to describe the absolute level of risk associated with a particular clothes cleaning operation to specific populations or individuals. Results often represent case studies, however, these case study scenarios may not be representative of or generalizable to common practices. For instance, data on performance are reported from real world performance demonstrations conducted in model clothes cleaning facilities that may or may not be representative of a cleaner's specific operation. Additionally, there is not a consistent level of performance information available across all technologies. Cost information, developed from literature and through contact with industry representatives, is generalized and may overestimate or underestimate costs for a specific operation. Exposure, hazard, and risk assessments for the chemical components of the cleaning technologies were made by USEPA based on available data and/or modeling. Assumptions used in developing the information in the CTSA are presented throughout to assist users in determining the applicability of the information to various clothes cleaning operations. It is reasonable to expect that actual risks, costs, and performance may vary for specific clothes cleaning operations.

DESIGN FOR THE ENVIRONMENT GARMENT AND TEXTILE CARE PROGRAM

The CTSA is a small part of DfE's Garment and Textile Care Program. The Program's mission is to assist in providing the professional garment and textile cleaner with a wider range of environmentally friendly options which they can offer to their customers, while maintaining or increasing economic viability. The objective is to promote not only cleaner production in the manufacture of garments and textiles, but also to promote production of garments and textiles that will facilitate the use of clean technologies by the professional fabricare provider in meeting consumer needs.

USEPA's interest in PCE exposures from drycleaning developed after learning about air emissions and water releases of the chemical. PCE has been documented in air, soil, and sediments and has been found in 771 out of 1,190 National Priorities List sites (ATSDR, 1995). In May 1992, USEPA convened the International Roundtable on Pollution Prevention and Control in the drycleaning Industry. One of the outcomes of the International Roundtable on Drycleaning was recognition of the need to both prevent pollution and reduce exposures to PCE in the drycleaning industry. USEPA has published some materials that examine pollution prevention in the drycleaning industry. Included is *The Product Side of Pollution Prevention: Evaluating the Potential for Safe Substitutes*, which evaluates the "...possibility of dramatic reductions in toxic chemical releases by focussing on safe substitutes..." (USEPA, 1994) and which contains sections specific to PCE. In this document, CTSA builds on that approach and introduces additional information on PCE and alternative technologies that is useful for examining alternatives for pollution, exposure, and risk reduction in a business environment.

CTSA RESULTS

Several technology alternatives to PCE drycleaning are available for commercial fabricare (generally referred to as clothes cleaning throughout). They are categorized as dry and wet cleaning processes, distinguished by the type of solvent used. Drycleaning refers to technologies based on non-aqueous solvents, while wetcleaning refers to processes based on water as a solvent. The CTSA covers PCE, hydrocarbon (HC) (including Stoddard, 140°F, and DF-2000 solvents), and machine wetcleaning (MWC) processes.

Several alternative modifications and machine configurations for the most prevalent technologies, PCE and HC dry cleaning, are also examined in the CTSA. They are compared on the basis of relative releases of solvent and costs to provide information to current PCE or HC users on the trade-offs associated with reducing solvent emissions, and possibly exposure, through process modifications.

The information in the CTSA is primarily focused on the use of chemicals in the various cleaning processes. Therefore, lifecyle considerations are not a part of the CTSA. Spotting chemicals, although used in many commercial clothes cleaning operations, are not included in this document, nor are chemicals in other formulations, such as fabric finishes and water softeners. An exception is coverage of detergents used in the machine wetcleaning process. USEPA has developed example formulations for which individual chemical components are examined in the CTSA. These formulations and component chemicals are presented for illustrative purposes. Numerous detergent formulations are currently available, and it is not clear how representative USEPA's sample may be.

Effects

Possible health, environmental, and safety concerns are described for each of the clothes cleaning processes. These possible effects range from cancer for PCE to a variety of noncancer effects, such as neurotoxicity for HC, and skin irritation for the several components of the sample detergent. The CTSA does not, nor is it intended to, represent the full range of hazards that could be associated with clothes cleaning technologies. These effects have been associated with these chemicals in laboratory tests and they may not occur in humans.

Environmental effects data are reviewed, and an environmental hazard ranking for aquatic toxicity of the individual solvents and detergent chemicals is included where data allow. The rankings range from low to high concern. Those of high concern include the HC solvents (Stoddard, 140°F, and DF-2000 solvents). While water, the primary solvent in machine wetcleaning, is not of concern for aquatic toxicity, there is concern for the detergents used. While used in small amounts (e.g. approximately 1% of total volume of solvent and additives [Industry Contacts, 1998]) relative to the process solvent, water, based upon EPA's sample formulation, some detergent components of the example detergents may be associated with aquatic toxicity. Some characteristics of detergent components, such as ability to biodegrade and chemical persistence, will affect whether actual detergents are associated with aquatic toxicity.

Three chemicals are of additional concern due to fire hazard. These chemicals are Stoddard solvent, 140°F solvent, and DF-2000, although the concern is lessened for 140°F solvent and DF-2000 due to their high flashpoints.

Releases

The CTSA presents estimated environmental releases of CTSA covered chemicals from facilities that clean clothes. These estimates are used in evaluating health and environmental impacts of the chemicals released and in examining the costs of the the processes. The CTSA relies heavily upon information in published literature to generate release estimates. However, published literature contains very limited information on most factors affecting chemical releases, including process type and operating procedures. Therefore, it was not possible to examine the relative impact that many of these factors have on releases. As a basis for comparing processes, theoretical "model facilities" were developed. Releases were estimated for eight PCE, three HC, and two machine wetcleaning model facilities.

The HC model facilities generally release the highest average volumes of solvent and solvent-containing wastes, followed by the PCE model facilities[1]. The PCE and HC model facilities with the fewest pollution control technologies release the highest volumes of chemicals to the air. These PCE and HC model facilities also generate solid wastes that in many cases are considered to be hazardous. PCE and HC model facilities release very small volumes of solvent into water. MWC model facilities generally release the lowest average volume of chemicals, and almost all of these releases are into water.

Exposures

[1] Releases for machine wetcleaning cover only detergent chemicals, not solvent (i.e. water).

There are a number of ways that people and the environment can be exposed to the chemicals from clothes cleaning processes. Exposed populations include workers, co-located residents, and the general population.

Workers in PCE and HC drycleaning facilities are exposed to solvents primarily by inhalation and dermal (skin) pathways. Workers in MWC facilities are exposed to detergents primarily by the dermal pathway. To characterize drycleaning worker inhalation exposures to the solvents, the CTSA has relied heavily upon personal monitoring data in published literature. Published literature contains limited information on most of the factors that affect exposure, including process type and operating procedures. Therefore, it was not possible to examine the relative impact that all factors have on worker exposures. All dermal exposures were modeled.

The inhalation data for PCE workers show several trends. There appears to be a general decreasing trend in exposure levels and PEL excursions over time. As expected, operators in facilities with transfer machines tend to have higher exposures than workers in facilities with dry-to-dry machines, and increases in the number of machines increases exposure levels. Closed-loop machines with integral carbon adsorbers (fifth generation) result in statistically significantly lower worker exposures than all other machine configurations currently available. Finally, the inhalation data for HC workers support the PCE data in showing that operators in drycleaning facilities generally receive higher average exposures than non-operators.

Workers in drycleaning facilities who transfer wet garments generally have higher dermal exposure potential than other workers, although PCE evaporates from the skin relatively quickly, limiting the potential dermal doses. HC evaporates from the skin more slowly than PCE, and the dermal doses of HC that drycleaning workers receive are potentially greater. MWC workers receive lower and less frequent potential dermal doses of detergents relative to potential dermal doses of solvents received by drycleaning workers.

Within the non-worker population, those most highly exposed to PCE are persons living in the same building as a drycleaner that cleans clothes on the premises (i.e., co-located residents). Monitoring studies show that the machine type and condition are important factors in the level of exposure. Generally, more sophisticated machines, with associated controls, produce lower fugitive emissions. However, even relatively advanced dry-to-dry machines can produce moderate to high PCE concentrations in co-located apartments (Wallace et al., 1995). PCE emissions from drycleaners are not expected to substantially increase exposures to the general population. Other types of general population exposure to PCE can occur from ingestion of contaminated drinking water and from wearing drycleaned clothes.

Monitoring data on HCs were not available, so exposures were modeled. The general population's exposure to HCs is expected to be low. General population dermal (skin) exposure to machine wet cleaning detergents was also modelled, and significant exposure is not expected.

Risk Estimates

The risk assessments were conducted at a "screening level" of review, using readily available information and standard analyses for completion. The risk assessments and characterizations give an idea of the potential risks to human health and the environment associated with each of the processes, however, careful interpretation is necessary given that the extent and type of hazard and exposure data and uncertainties associated with each process differ widely.

Perchloroethylene Solvent

There is a reasonable basis to conclude that there can be a health risk for cancer and some non-cancer effects to workers from the relatively high PCE exposures observed on average in the drycleaning industry. Based upon upper bound estimates, cancer concerns may also extend to residents living in co-location with drycleaning establishments, particularly if they live in such dwellings for more than several years. Non-cancer effects may also be a concern for co-located residents. In addition to their exposures related to co-location with drycleaning facilities, co-located residents are also at risk through a variety of PCE exposures that the general public experience, such as drinking PCE-contaminated water, or wearing dry-cleaned clothes. Adult risk does not translate directly to infants, children, and the elderly, although in scenarios where high risk levels have been determined for adults, there should be a concern for sub-populations exposed by similar routes at similar levels.

Given the release estimates developed in the CTSA, it does not appear that there is a concern for risk to aquatic species for the majority of dry cleaners who send their wastewater effluents to a publicly-owned treatment work.

Hydrocarbon Solvents

A major hazard identified with the HC solvents considered in the CTSA is their potential flammability. The National Fire Protection Association (NFPA) gives them a grading of "2" for flammability indicating that they must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. For comparison, PCE receives a grade of "0" for flammability which indicates that it will not burn. Data are not available to evaluate the risks of fire in drycleaning facilities due to use of these HC solvents. However, based on the NFPA's low flammability ranking, the risk of fire from HC use can be considered greater than the risk of fire due to PCE. In addition, the varying flashpoints of the three HC solvents examined suggests that the fire potential is lessened as one employs a higher flashpoint HC solvent. Of the HC chemicals examined in the CTSA, DF-2000 has the highest flashpoint, followed by 140°F solvent, and Stoddard solvent.

The health risk conclusions for the HC solvents in the CTSA are based upon findings for Stoddard solvent, however, there are no data suitable for drawing conclusions concerning carcinogenic potential. Worker exposures to HC solvents, especially the high end exposures, are indicative of a concern for non-cancer risk for workers. Although HCs can be toxic to aquatic organisms, they are not expected to be released in quantities that would pose a risk.

Machine Wetcleaning

Based upon the example detergent, there may be a risk to aquatic organisms from some of the constituents in detergents used in machine wetcleaning formulations. Potential risks are dependent on the local streamflow and water treatment conditions, as well as the specific chemicals used in actual detergent formulations. There is no expected health risk to the general public based on low expected exposures. Risk estimates could not be developed for workers due to lack of sufficient toxicity data.

SELECTED FEDERAL REGULATORY REQUIREMENTS

Professional clothes cleaners may be subject to numerous federal requirements. In addition, cities and municipalities have enacted numerous zoning restrictions that may affect all types of fabricare operations, and many localities have adopted some, or all, of the National Fire Protection Association's standards for drycleaning equipment and operations (NFPA-32). These restrictions and requirements have the potential to affect costs and liabilities of cleaning operations.

Exhibit ES-1 summarizes the federal regulations that may affect clothes cleaning operations covered in the CTSA. State and other requirements are not included. Requirements that pertain to the use of spotting chemicals and chemicals such as fabric finish and water softeners are not included, however, they should not be overlooked for their impact on a fabricare operation's regulatory compliance activities. Absence of regulatory requirements identified within the CTSA does not mean that federal, state, and local regulations are not applicable or will not apply in the future.

Exhibit ES-1. Summary of Regulations Related to Fabricare Technologies[a]

Fabricare Option	CAA	CWA	RCRA	CERCLA	OSH	Care Labeling Rule	Other
PCE cleaning	✓	✓	✓	✓	✓	✓	NFPA 32
HC cleaning	✓	✓	✓	✓	✓	✓	NFPA 32
Machine wetcleaning	NA	✓	NA	NA	NA	✓	NA

✓ Indicates that a technology is regulated specifically in statute.
NA Indicates that although the statutes apply to the technology there are no specific regulatory requirements.
[a] The list of regulations covered in this exhibit should not be considered exhaustive and may not cover all regulated aspects of the fabricare industry.

The two most prevalent technologies, PCE and HC drycleaning, are most affected by provisions of federal regulations. Machine wetcleaning currently has fewer requirements that are directly applicable. It is unclear how requirements may change as industry use of these technologies changes.

The Care Labeling Rule relates to all cleaning methods, although it does not contain specific requirements for cleaning garments. The rule requires manufacturers to label garments identifying acceptable cleaning methods. Garments that are cleaned in a manner other than that specified by the manufacturer and are subsequently damaged, are the responsibility of the cleaner. Manufacturers may cautiously label garments as "dryclean only" (Wentz, 1996; Riggs, 1998). In effect, this may constrain the cleaner interested in avoiding liability from utilizing wetcleaning processes.

Under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), potentially responsible parties that contribute to chemical contamination of a particular site, regardless of the intent or involvement of that party, are held strictly liable. Many sites with past and present PCE drycleaning operations are already contaminated to levels that will limit future uses of the property leading to liability considerations that may affect decisions regarding technology choices. Other liability concerns could result from worker claims for health effects resulting from chemicals used in clothes cleaning processes or from garment damage resulting from the various cleaning processes.

COSTS

The costs of running a professional clothes cleaning business include rent, basic operating expenses, and equipment. The equipment capacity, equipment type, and the location of the facility will also affect the costs and economic viability of a professional cleaning operation. The CTSA has focused on a subset of costs associated with operating clothes cleaning facilities.

Exhibit ES-2 summarizes the estimated process dependent cost components for the cleaning technologies covered in the CTSA. Cost figures are presented in constant 1997 dollars in order to allow direct comparisons among the process options.

Machine wetcleaning equipment, on average, is expected to cost less to purchase that PCE or HC drycleaning equipment. The average total operating cost per pound is expected to be higher for PCE and HC than for machine wetcleaning. One of the more significant operating costs for the drycleaning technologies is the cost of hazardous waste disposal. These costs are estimated to be highest for HC because of the volume of hazardous wastes released. However, wastes from certain HC processes, particularly those using the higher flashpoint solvents such as DF-2000 and 140°F solvents, are less likely to have significant amounts of hazardous waste generated from the cleaning process. Therefore, HC costs, on average, are likely to be close to those for PCE. No hazardous waste costs are assumed for machine wetcleaning, however, certain components of detergents or spotting chemicals may be hazardous waste in actual machine wetcleaning facilities.

PERFORMANCE CHARACTERISTICS

Several factors may affect the performance of a cleaning process, including soil chemistry, textile fiber type, transport medium (aqueous vs. non-aqueous), chemistry of additives (e.g., detergents) use of spotting agents, and process controls (time, temperature, and mechanical actions). These factors work interactively to provide a range of cleaning abilities for all clothes cleaning processes. In addition, customer perceptions of a “clean” garment will vary. Finally, variations in technology and the knowledge base of operators may also affect performance of the clothes cleaning process.

Exhibit ES-2. Summary of Estimated Process-Dependent Cost Components for Selected Fabricare Technologies[a]

Fabricare Technology[b]	Capital Cost of Base Equipment[c]	Capital Cost Total[d]	Annualized Cost of Equipment[e]	Annual Cost of Solvent[f]	Annual Energy Cost[g]	Regulatory Compliance Costs[h]	Annual Cost of Hazardous Waste[i]
PCE	$38,511	$38,511	$4,228	$1,434	$136	$3,680	$4,594
HC	$37,432	$37,432	$4,110	$2,236	NA	NA	$9,820
Machine Wetcleaning	$11,102	$11,102	$1,219	$763	$788	NA	NA

Exhibit ES-2. Summary of Estimated Process-Dependent Cost Components for Selected Fabricare Technologies (Cont'd)

Fabricare Technology	Annual Cost of Filters and Detergent[j]	Annual Cost of Maintenance[k]	Total Annual Operating Cost[l]	Total Annual Cost[m]	Total Annual Cost/Pound
PCE	$1,913	$6,000	$14,077	$18,305	$0.34
HC	$1,551	$6,000	$19,607	$23,717	$0.44
Machine Wetcleaning	$3,162	$376	$5,089	$6,308	$0.12

NA means cost category not applicable for technology or that data are not available at this time.

[a] The values include the price of equipment, labor and services directly related to the various drycleaning processes, but exclude costs for pressing, storefront operations, and rent. All values are in 1997 dollars and all calculations assume a 53,333 pound (24,191) annual volume of clothes cleaned per facility. Costs are meant to provide relative comparisons and may differ for specific fabricare operations.
[b] Configurations for fabricare technology include: PCE dry to dry closed-loop with no carbon adsorber or with door fan and small carbon adsorber (PCE-C), as required by the PCE NESHAP regulation; HC Transfer with Recover dryer and condenser (HC-A2); and Unimac UW30 washer and DTB50 dryer.
[c] List price of 35 pound PCE drycleaning system includes control equipment, distillation unit, and filters; List price 35 to 40 pound HC drycleaning system includes control equipment, filters, and an explosion kit.
[d] Base machine costs (actual or implied) are added to cost of control capital.
[e] Annual cost of drycleaning equipment, annualized using 7% interest and assuming equipment life of 15 years.
[f] PCE solvent cost based on $6.83 per gallon for PCE in 1997 dollars (BLS, 1997; USEPA, 1993a) and "mileage" from EPA engineering estimates; HC solvent cost based on $2.24 per gallon for hydrocarbon solvent and "mileage" based on engineering estimates; wetcleaning solvents cost based on $3.06/100 feet^3 for water (BLS, 1997; USEPA, 1993a).
[g] All technology energy costs are based (USEPA, 1991a) on $0.0764/kWh national average electricity cost (BLS, 1997).
[h] Regulatory compliance costs for PCE are based on 1.84% of total annual revenues of $200,000 (Gottlieb et al., 1997; NCAI, 1998).
[i] Hazardous waste disposal costs for PCE and HC based on $6.94 per gallon disposal cost (Beedle, 1998) and volume calculations from EPA engineering estimates, excluding disposal cost for potentially hazardous spotting chemicals. Hazardous waste associated with PCE-based machines includes filters, distillation residues, and spent carbon. Hazardous waste associated with HC-based machines includes spent cartridge filters and vacuum still bottoms.
[j] Cost includes of cleaning detergents, spotting chemicals, and replacement filters (Hill, Jr., 1994; USEPA, 1993a).
[k] Annual maintenance cost for PCE and HC based on 3.0% of total revenues of $200,000 annually; costs for machine wetcleaning based on 3.39% of total capital costs (Murphy, 1994).
[l] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.
[m] Includes all operating costs and annual capital costs.

Although there is insufficient information to characterize the cleaning performance of each of the cleaning technologies considered in this document, some general comparisons are possible between drycleaning and wetcleaning processes. Drycleaning processes are more effective at dissolving oils and fatty stains (non-polar soils), while wetcleaning processes tend to dissolve sugar, salt, and perspiration (polar stains) with greater success. It is unclear whether particulate soils are better handled by one process type or the other. The cleaning ability of both wet and drycleaning processes may be enhanced with the use of spotting agents, detergents, surfactant additives, and other process modifications (time, temperature, mechanical action).

These two types of cleaning processes also excel at cleaning different kinds of materials. Drycleaning processes are most effectively used with textiles that contain water-loving (hydrophilic) fibers (such as wool), low twist yarns, low count fabrics, and polar colorants. Wetcleaning processes are effective with textiles containing water-hating (hydrophobic) fibers (such as polyester and nylon), high twist yarns, high count fabrics, and non-polar colorants. Wetcleaning methods tend to cause expansion of natural and cellulose fibers, leading to a loss of strength, wrinkling, color loss, and dimensional change (shrinkage, stretching). However, textile manufacturers have developed a number of fiber treatments and modifications (resin preparation, shrink prevention preparation, wool felt prevention) that may minimize such cleaning impacts on clothing. Such alterations are not necessarily apparent when synthetic fibers are subjected to similar water-based cleaning methods. Drycleaning methods, however, may not be appropriate for synthetic fibers due to potential fiber deterioration.

OTHER FACTORS

Because different cleaning processes are more effective with certain types of materials and/or certain types of soils, and because the effectiveness of all cleaning processes may be enhanced by certain process modifications, it is difficult to draw any general conclusions concerning the relative performance of the cleaning technologies considered in this document.

There are several other factors that may affect a clothes cleaner’s decision. These may include consumer issues beyond performance, such as odor in clothing, liability concerns, and the current state and availability of alternatives. These factors can affect the costs faced by the cleaner, customer satisfaction, or ability to select alternatives.

PCE has been known to leave an odor in drycleaned clothing. Similar odor concerns exist for several of the HCs, however; the manufacturer of DF-2000 claims that it leaves no odor. Machine wetcleaning processes do not have odor problems associated with them.

SUMMARY OF TRADE-OFF CONSIDERATIONS

Each of the factors summarized above may affect the technology choices made by clothes cleaners. Cleaners must consider the costs of running an operation and the service that they can provide to consumers. Choices may be limited by regulatory requirements and levels of necessary capital investment. The effects of technology choice on the health and well-being of the environment and individuals exposed to the chemicals and to the cleaning process are also important factors. Many of these considerations are summarized in the CTSA and are organized and presented in Exhibit ES-4.

EMERGING TECHNOLOGIES

Several fabricare processes are currently under various stages of commercial development. As a result of their emerging status, information on them ranges from anectdotal study to results. The CTSA presents some information on these technologies, describing processes, estimated capital costs, and claims about technology performance. However, the developmental nature of these process alternatives does not allow for comparison with the existing technologies. The emerging technologies covered include liquid carbon dioxide (CO_2) drycleaning, propylene glycol ether (Rynex) solvent, ultrasonic wetcleaning, and Biotex solvent. Much of the information comes from vendors and can not be independently verified at this time; however, it is useful in providing an indication of fabricare technologies that may become viable alternatives for drycleaners.

CONCLUSIONS

During the time that this CTSA has been under development, the fabricare industry has gone through major changes. Drycleaners have significantly reduced PCE consumption, established a new commercially viable cleaning process, machine wetcleaning, developed lower flashpoint hydrocarbon solvents, and witnessed the development of a number of emerging technologies. As would be expected, the CTSA, which is based on available information, includes a significant amount of information on PCE and HC technologies, less on machine wetcleaning, and almost nothing on the emerging technologies. As new information becomes available, EPA will make it publicly available through case studies and fact sheets from its DFE Garment and Textile Care Program.

The CTSA demonstrates that each of the fabricare processes may have health and environmental implications associated with their use. It does not provide estimates of risks from individual fabricare operations, but identifies the most significant health and environmental concerns associated with each process. Clearly identified are the possibility of risks of cancer to individuals highly exposed to PCE, flammability hazards from some of the HC solvents, and possible considerations for the environmental release of detergents from machine wetcleaning (depending upon the actual chemical components). Cost data in the CTSA show which factors may contribute most to the costs of a particular technology choice, and how these costs may compare relative to the costs of other technologies. The CTSA relates the results of performance studies that describe customer satisfaction and effectiveness of the Machine Wetcleaning process. The information on emerging technologies is general, reflecting what is known at this time about liquid CO_2 and ultrasonic cleaning, and Rynex and Biotex solvents.

Exhibit ES-3. An Overview of Alternative Cleaning Technologies' Trade-Off Factors[a]

Characteristic	PCE	HC	Machine Wetcleaning
Health and Environmental Risks	**Health:** Risk of cancer to workers, co-located residents. Risks of non-cancer effects, including potential for developmental and reproductive effects for workers. May be cancer and non-cancer risks to co-located children. **Environmental:** Potential risk to aquatic organisms for effluent not treated by a POTW.	**Health:** Risk of neurotoxic effects and skin and eye irritation for workers. **Fire:** Highest for Stoddard solvent, less for 140°F and DF-2000, based on flashpoint **Environmental:** Potential to contribute to smog and global warming.	**Health:** Risk not evaluated quantitatively. Potential risks of skin and eye irritation for workers. **Environmental:** Potential risk to aquatic organisms from specific detergent component releases.
Costs[b]			
Potential liability costs	Groundwater contamination and worker illness.	Fire damage.	Damaged clothing labeled "Dryclean Only."
Capital costs[c]	$38,511	$37,432	$11,102
Hazardous waste disposal[d]	$4,594	$9,820	NA
Annual operating costs[e]	$14,077	$19,607	$5,089
Total annual costs[f]	$18,305	$23,717	$6,308
Market Considerations			
State of technology	Dominant in market.	Well-established in market; use of some HCs may be limited by local fire codes.	Commercial use since 1994 in U.S.; numerous detergent suppliers.
Consumer Issues			
Odor	Yes	Yes, maybe less for particular HCs	No
Cleaning Performance	Wide range of clothes.	Wide range of clothes.	Wide range of clothes.

NA means cost category not applicable for technology.

[a] Configurations for fabricare technology include: PCE dry-to-dry closed-loop with no carbon adsorber or with door fan and small carbon adsorber (PCE-C), as required by the PCE NESHAP regulation; HC Transfer with Recover dryer and condenser (HC-A2); and Unimac UW30 washer and DTB50 dryer.
[b] The values include the price of equipment and services directly related to the various fabricare cleaning processes, but exclude costs for pressing, storefront operations, and rent. All values are in 1997 dollars and all calculations assume a 53,333 pound (24,191) annual volume of clothes cleaned per facility.
[c] List price of 35-pound PCE drycleaning system includes control equipment, distillation unit, and filters; list price of 35- to 40-pound HC drycleaning system includes control equipment, filters, and an explosion kit.
[d] Hazardous waste disposal costs for PCE and HC based on $6.94-per-gallon disposal cost (Beedle, 1998) and volume calculations from EPA engineering estimates; HC solvent waste may not be considered hazardous waste under the Resource Conservation and Recovery Act. Therefore, this is a high-end estimate. Hazardous waste costs associated with spotting chemicals or certain detergent components are not included.
[e] Includes solvent, energy, hazardous waste, filters, detergent, and maintenance costs. The cost of labor, another component of annual operating costs, is omitted due to lack of data.
[f] Includes all operating costs and annual capital costs.

The CTSA offers guidance on the most important factors for comparing technologies. Individual cleaners would need to apply these general considerations to the specifics of their operation in order to make reasoned technology choices. Since the information contained in the CTSA is highly technical, additional information products are expected to be developed to assist in dissemination of the results. Currently, DfE's Garment and Textile Care Program is developing a condensed version of the CTSA.

Through its DfE Garment and Textile Care Program, EPA also plans to continue work in the fabricare industry. Plans are to expand the Program's core base of stakeholders by increasing representation from upstream industries such as textile and garment designers and manufacturers. The broader circle of stakeholders will continue to work collaboratively to further integrate pollution practices into the fabricare industry. EPA hopes that the CTSA, as well as future efforts, will encourage improvement and expansion of new fabricare choices and remove barriers that prevention adoption of economically competitive and environmentally sound processes.

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